Nitrogen availability from organic amendments

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Organic fertilizers and composts are valuable sources of nutrients. However, their nutrient availability is often not known and can be variable. When soil microorganisms decompose organic materials, they use some of the nitrogen (N) in these materials to produce protein and other cell components. When the materials contain excess N, the microorganisms release plant-available ammonium into soil solution. This process is called N mineralization. In contrast, most N in organic amendments is not directly plant-available. Therefore, N mineralization increases the pool pf plant available N in the soil. How much N is mineralized depend on environmental factors, especially temperature and so moisture, as well as the properties of the decomposing organic material. Especially the carbon to N (C:N) ratio has a strong effect on N mineralization. We investigated the effects of C:N ratio in a study where we mixed different commercially available organic fertilizers and composts with moist soils and kept them at 73 °F for 12 weeks (Lazicki et al., 2020). The results indicate that the C:N ratio is a good measure to determine the availability of N (Figure 1). Materials with a C:N ratio of 5 or less released 70% or more within 12 weeks. Examples of such materials are guano, feather meal or blood meal. In contrast, materials with a C:N ratio of about 17 or higher hardly mineralized N or even immobilized some N from soil solution during the 12 weeks of incubation. Nitrogen immobilization reduced to pool of plant available N.

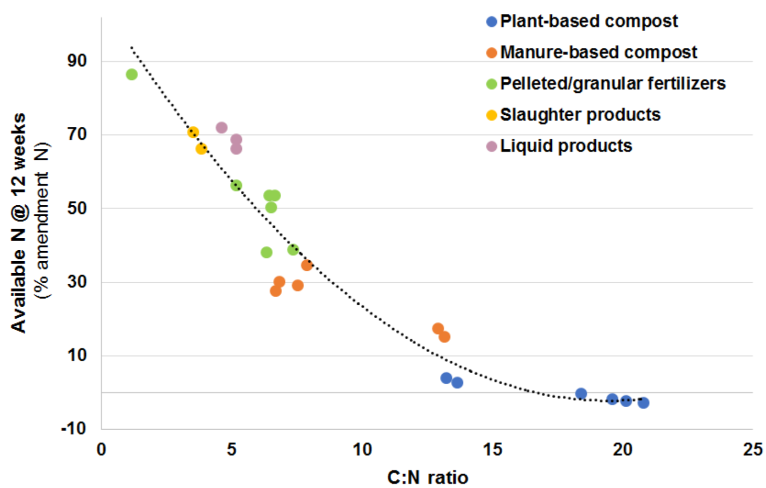

Figure 1: Relationship between the proportion of N in the mineral form after 12 weeks of incubation at 73 °F and amendment C:N ratio (Lazicki et al., 2020).

We also found that different batches of the same material can have quite variable properties and thus N mineralization capacities. To get a better idea of this variability, we searched the scientific literature for studies where different materials were incorporated into moist soil and found more than 100 datasets (Table 1). Comparing the results from different studies is challenging, because the protocols used differ widely in terms of temperature and duration. To overcome this challenge, we used a model that allowed us to determine N mineralization rates in these studies as if they all had been carried out for 100 days at a temperature of 77 °F.

Table 1: Characteristics of the materials included in our analysis (Geisseler et al., 2021).

Material	Datasets	C to N ratio		Initial mineral N
		Average	Range	(% of total N)
Guano	8	2.8	1.2 - 3.8	2.2 - 55.1
Feather meal	14	4.0	3.3 - 10	0 - 16
Poultry manure	29	10.3	6.3 - 19.5	3.3 - 36.8
Poultry manure compost	16	7.3	5.7 - 9.4	12.6 - 25.1
Vermicompost	21	11.1	14.9 - 35	1 - 17.8
Yard waste compost	25	16.1	9.1 - 22.3	0.1 - 8.4

The results revealed that N from guano and feather meal becomes rapidly plant available (Figure 2). A slightly larger proportion of the total N in guano becomes plant available within 100 days of incorporation into warm and moist soil (70-75%) than for feather meal (50-65%). With both materials, most of the N was released within the first 20 days of the simulated incubation. Studies have shown that feather meal has a very similar N mineralization pattern to fish powder, while a slightly larger proportion of the N becomes available when blood meal is incorporated into soil.

The properties of poultry manure can be highly variable. In the 29 datasets included in our analysis, the C:N ratio ranged from 6.3 to 19.5. In our datasets, 16.3% of total N was on average present as mineral N in the material. At the end of the 100-day simulation period, between 24 and 47% were in the mineral form. Poultry manure as a fertilizer type is highly heterogeneous. Some of the factors contributing to this heterogeneity are amount and type of bedding material, conditions during storage, processing (e.g. pelleting) and particle size.

The poultry manure composts were a more homogeneous group than the fresh poultry manures. This may be in part due to the smaller dataset of 16, but also reflects the fact that composting generally results in the buildup of more recalcitrant material and reduced N mineralization. Between 13 and 25% of the total N in the poultry manure composts were in the mineral form at the start of the incubations. At the end of the 100-day simulation, between 30 and 35% of the total N from a material with an average C:N ratio was in the mineral form. The poultry manures included in our study were all mature, stable composts. Some materials marketed as poultry manure compost may not have reached a stable form. Therefore, the variability observed in practice may be bigger than our dataset suggests.

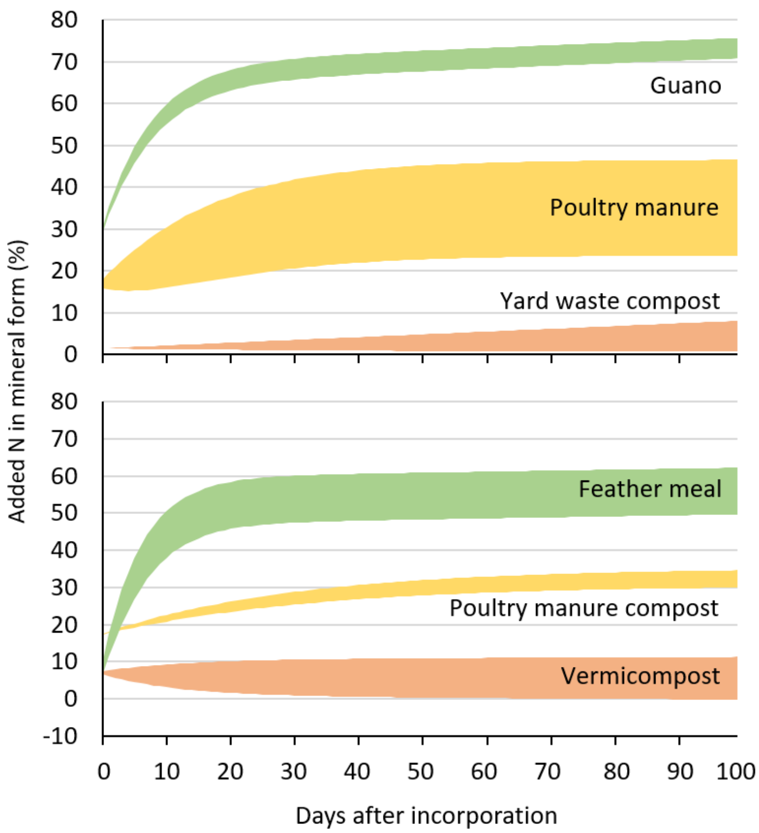

Figure 2: Simulated nitrogen turnover from organic fertilizers and composts based on minimum and maximum C:N ratios from a literature survey. The calculations assumed optimal moisture content and a constant temperature of 77 °F (Geisseler et al., 2021).

The yard waste composts included in our analysis had a relatively wide C:N ratio ranging from 9.1 to 22.3. The type of raw material used is a major factor contributing to this variability. Yard waste compost is a stable material and its N is mineralized slowly. Generally less than 10% of the total N is mineralized during a growing season. Materials with a wider C:N ratio may even immobilize N. This means that a large proportion of yard waste compost is left in the soil contributing to an increase in soil organic matter content and soil fertility when applied regularly.

The N mineralization pattern of vermicompost is similar to yard waste compost. An important difference between the two materials is that vermicompost can contain mineral N, which is directly plant available when applied.

Based on the results from our study, we developed an interactive tool that allows users estimating mineralization rates of incorporated organic materials based on local soil temperatures and material properties. The tool is available online at http://geisseler.ucdavis.edu/Amendment_Calculator.html

References (both articles are open access)**:**

Geisseler, D., Smith, R., Cahn, M., Muramoto, J., 2021. Nitrogen mineralization from organic fertilizers and composts: Literature survey and model fitting. Journal of Environmental Quality 50, 1325–1338. https://doi.org/10.1002/jeq2.20295

Lazicki, P., Geisseler, D. Lloyd, M., 2020. Nitrogen mineralization from organic amendments is variable but predictable. Journal of Environmental Quality 49, 483–495. https://doi.org/10.1002/jeq2.20030